Does traditional hatchery production help conserve wild salmon -- a comment on the Fall Creek coho hatchery controversy

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With the expanded listing of Pacific salmon populations under the U.S. Endangered Species Act (ESA), efforts by state and federal management agencies to reform hatchery practices are receiving increasing attention. For example, over the last three years the Oregon Department of Fish and Wildlife (ODFW) has eliminated coho salmon production at the Fall Creek Hatchery in the Alsea River. Stopping production of the Fall Creek stock is part of an effort to recover wild Oregon coho salmon, but it has created an outcry of opposition from people who favored continued production of hatchery coho salmon in the Alsea watershed.

For example, Jim Lannan, a retired Oregon State University professor, has recently criticized the National Marine Fisheries Service (NMFS) and ODFW's approach to hatchery production of Pacific salmon, especially with regard to the ending of Fall Creek coho production[1]. In this article we explain why we believe the ODFW's decision to stop producing the Fall Creek Hatchery stock will help natural Alsea River coho salmon, and explain the scientific rationale behind the NMFS's hatchery policies. Efforts to reform hatcheries are ongoing throughout the Northwest and controversies similar to what occurred in the Alsea River watershed will surely arise again.

Was the Fall Creek Hatchery stock helping natural coho populations?

To begin answering this question, it is worth considering the following study. In the early 1980s, Tom Nickelson and his colleagues at the ODFW conducted a controlled experiment in which they tracked the abundance of coho salmon in 30 streams. Half the streams were supplemented with hatchery presmolts from the Fall Creek and similar hatchery stocks and half were left as unsupplemented controls[2]. The researchers found that total parr densities initially increased in the stocked streams. However, wild parr in the stocked streams decreased, apparently due to competition from larger hatchery fish. Adult abundance remained similar between the stocked and control streams during the experiment, but after stocking ceased juvenile densities were actually significantly lower in the stocked streams than in the control streams (Figure 1). The researchers concluded that the early spawn timing of the hatchery fish was largely to blame for the lack of sustained increases in the supplemented streams. The early spawners produced early emerging fry that were washed away by late winter freshets, reducing the fitness of the stocked populations compared to the unstocked controls.

As this example demonstrates, hatcheries have risks for natural populations as well as potential benefits. The major potential benefit of hatcheries is obvious: the same number of parents can often produce more offspring in a hatchery than they could in the wild. The ecological and genetic risks to wild fish are more subtle. Two important ecological risks include competition between hatchery and wild fish and predation by hatchery fish on wild fish. Genetic risks include losses of genetic variation and intentional or unintentional selection for traits that are benign or advantageous in the hatchery but disadvantageous in the wild (e.g., early spawn timing). Genetic variation

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[1] Oregon Fish & Wildlife Journal, January/Feburary 2000.
[2] Canadian Journal of Fisheries and Aquatic Sciences 43:2443-2449.

can also be lost due to poor broodstock management, such as by using a very small number of breeders.

With regard to genetic risks, scientists have known for decades that salmon spawned and reared in hatcheries tend to become different from their wild ancestors. For example, in the 1970's Oregon researchers found that egg-to-fry survival of Deschutes River hatchery steelhead planted in the wild was only ~80% of the survival wild Deschutes River steelhead in the same stream[3]. Using similar methods, researchers in Washington estimated that the mean lifetime fitness of naturally spawning hatchery fish in the Kalama River, Washington, was only ~10% that of natural fish[4].

In addition to having lower survival in the wild environment, hatchery-produced fish often differ from wild fish in their behavior, appearance, or physiology. For example, Canadian researchers found that the courting frequency and breeding success of hatchery coho salmon was significantly worse than fish from nearby wild populations (Figure 2)[5]. Additional examples of studies documenting differences in the appearance and behavior of wild and hatchery fish are found in Table 1. If these differences are genetically based (as many of them are known or suspected to be), then overwhelming wild populations with large numbers of genetically modified hatchery fish will reduce the genetic fitness of the wild populations.

Looking specifically at the fall Creek coho stock, there are three factors that strongly suggest producing the stock and letting the returning hatchery fish spawn in the wild was harming wild Alsea River coho salmon. First, the Fall Creek stock had been hatchery produced for over ten coho salmon generations, with no attempts to maintain wild fish characteristics. Based on research on other salmon stocks, coho salmon propagated this way will probably have lost the attributes they need to thrive in the wild (Table 1). Second, by the 1990's the Fall Creek stock's spawn timing was significantly earlier than it was when it was founded. It was also earlier than the spawn timing of wild coho salmon in the Alsea River watershed (Figure 3). Early spawn timing is common for hatchery stocks, and is probably due in part to use of earlier returning spawners for broodstock. Third, a controlled scientific experiment demonstrated *less* natural production in streams where the Fall Creek stock (and similar stocks) presmolts had been planted than in unstocked streams (example above). We therefore conclude that the ODFW had sound biological reasons for stopping the production of the Fall Creek coho hatchery stock.

Are the NMFS's hatchery policies biologically based?

The NMFS is the federal agency that administers the ESA for Pacific salmon. The stated purposes of the ESA are to provide a means **whereby the ecosystems upon which**

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[3] Reisenbichler, R. R., and J. D. McIntyre. Journal of the Fisheries Research Board of Canada 34:123-128.
[4] Leider, S. A., P. L. Hulett, J. J. Loch, and M. W. Chilcote. Aquaculture 88:239-252.
[5] Fleming, I. A., and M. R. Gross. Ecological Applications 3:230-245.

endangered and threatened species depend may be conserved, to provide a program for conserving such species, and to take the steps needed to achieve these purposes[6]. The ESA's focus is, therefore, on natural populations -- the progeny of naturally spawning fish -- and the ecosystems upon which they depend. The biological reason for this is simple -- it is impossible to conserve the world's biodiversity without protecting the environment and ecosystems that species need to survive. Artificial propagation can potentially save a species from extinction in the short term, but it does nothing to address the underlying causes of the species' decline in the wild.

Despite this emphasis on maintaining species in their natural habitat, the ESA recognizes that artificial propagation can sometimes help the conservation of listed species. In fact, artificial propagation has been an important element in draft recovery plans for several Pacific salmonid species. In many cases the NMFS includes hatchery salmon as part of the listed species and gives them the full protection of the ESA. However, hatcheries can have both potential benefits and risks to natural populations, and the NMFS must balance these benefits and risks. This balancing act is performed in three steps[7]:

Step 1: Determine whether or not specific hatchery populations are representative of the group of natural populations that is being listed. This is an entirely biological question, based primarily on the history of the hatchery population in question. In general a hatchery population will be considered biologically part of the listed group if it was derived from the natural populations in the listed group *and* if it has not become substantially domesticated. The Fall Creek stock was derived nearly entirely from Oregon Coastal coho populations, but was not considered part of the listed group because there was good evidence that the stock had become substantially domesticated and was no longer representative of the natural populations that were being listed under the ESA.

Step 2: For those hatchery stocks that are considered biologically representative of the natural populations being listed, determine whether or not to actually list the hatchery-produced fish under the ESA. This is partly a biological and partly an administrative question based on the purpose of the hatchery program. If the hatchery population is used to benefit the listed species, then the hatchery produced fish will receive protection under the ESA, either immediately at the time of listing or over a period of several years as wild fish are incorporated into the hatchery broodstock. On the other hand, if the hatchery population is used in manner that does not benefit the listed species (e.g., if the hatchery program is primarily producing fish for harvest), then the hatchery fish will not be listed. All hatchery fish that the NMFS considers to be essential for the survival and recovery of the species will be listed and used for conservation purposes.

Step 3: For those hatchery programs that are intended to aid in the conservation of the listed species, conduct a thorough analysis of the benefits and risks to determine if a net biological benefit is likely to be achieved. This analysis is based entirely on biological criteria. The likelihood of a net benefit will depend both on how the program is designed

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[6] ESA sec. 2(b), emphasis added
[7] See also Federal Register 58:17573-76

and implemented, as well as the status of the natural population proposed for supplementation. It is therefore essential to determine in each specific case whether the potential benefits outweigh the risks.

In summary, the Endangered Species Act emphasizes the conservation of natural ecosystems -- the substitution of artificially propagated populations for natural populations does not meet the goals of the Act. Multiple scientific experiments and observations indicate that in addition to potential benefits, hatchery production can have substantial genetic and ecological risks for natural salmon populations. In applying the ESA to Pacific salmon, the NMFS has developed a biologically based strategy for balancing these potential benefits and risks. Given the data available, it is highly improbable that continued propagation of the Fall Creek Hatchery coho salmon stock would have benefited the natural Alsea River coho salmon population. Indeed, it is much more likely that the propagation of Fall Creek stock was contributing to the decline of natural Alsea River coho salmon.

Figure 1 -- Differences in juvenile coho densities in stocked and unstocked streams on the Oregon coast (after Nickelson et al. 1986)

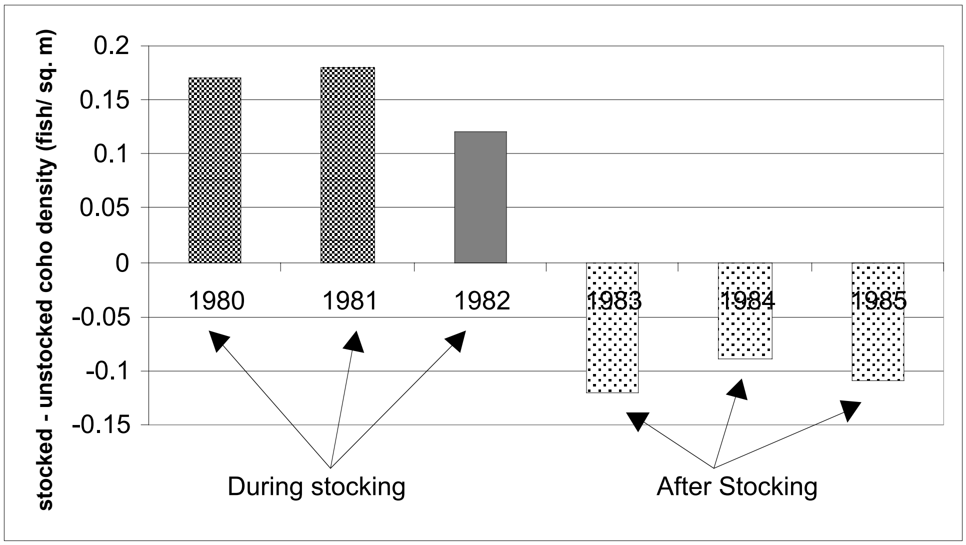

Figure 2 -- Courting frequency and breeding success of hatchery and wild coho salmon (after Fleming and Gross 1993)

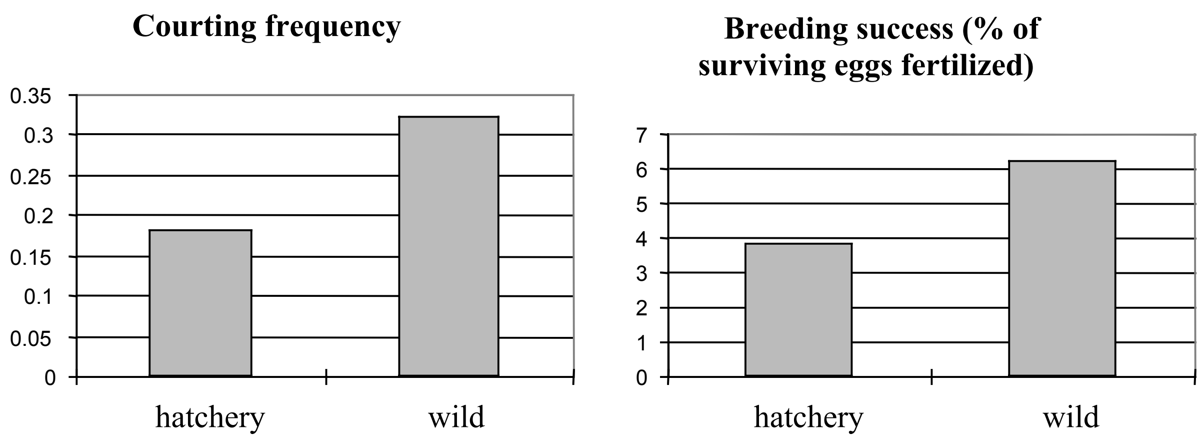

Figure 3 -- Peak spawning timing natural and hatchery coho salmon in the Alsea River. The data plotted for the Fall Creek Hatchery are the median spawn dates (NRC 1995). The rest of the plotted data are observed times of peak coho salmon spawning in several Alsea River tributaries (ODFW, unpublished data). The median spawn timing of the Fall Creek stock is significantly earlier in the period from 1983 to 1994 than from 1950 to 1963 (t-test, $p < 0.01$).

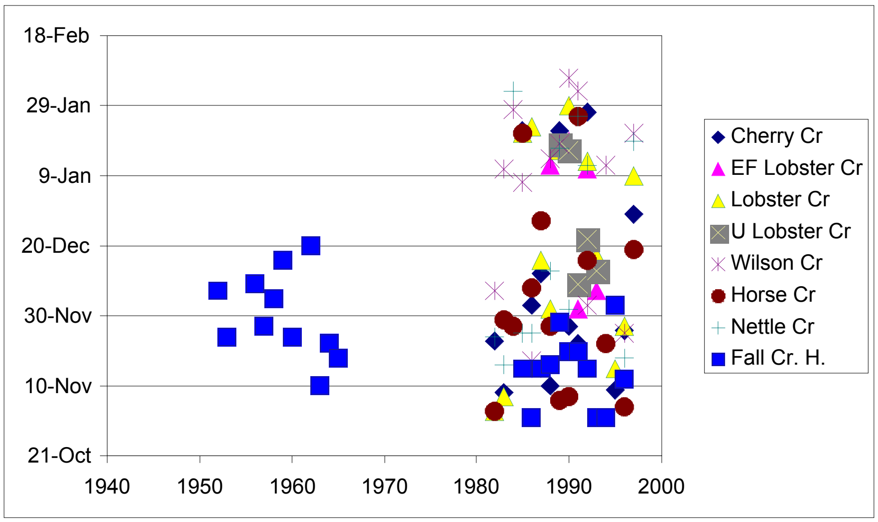

Table 1 - Examples of scientific studies that have found differences in behavior or appearance between hatchery and wild salmonids

Berejikian, B.A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (Oncorhynchus mykiss) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52:2476-2482.

Berejikian, B.A., Tezak, E.P., Schroder, S.L., Knudsen, C.M. and J.J. Hard. 1997. Reproductive behavioral interactions between wild and captively reared coho salmon (Oncorhynchus kisutch). J. Marine Sci. 54: 1040-1050.

Chilcote, M.W., Leider, S.A. and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Trans. Am. Fish. Soc. 115:726-735.

Fleming, I.A. and M.R. Gross. 1989. Evolution of adult female life history and morphology in a Pacific salmon (coho: Oncorhynchus kisutch). Evolution 43:141-157.

Fleming, I.A. and M.R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (Oncorhynchus kisutch): does it differ? Aquaculture 103:101-121.

Fleming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (Oncorhynchus kisutch) in competition. Ecological Applications 3:230-245.

Fleming, I.A. and M.R. Gross. 1994. Breeding competition in a Pacific salmon (coho: Oncorhynchus kisutch): Measures of natural and sexual selection. Evolution 48:637-657.

Leider, S.A., Hulett, P.A., Loch, J.J. and M.W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture 88:239-252.

McGinnity, P., Stone, C., Taggart, J.B., Cooke, D., Cotter, D., Hynes, R., McCamley, C., Cross, T. and A. Ferguson. 1997. Genetic impact of escaped farmed Atlantic salmon (Salmo salar L.) on native populations: use of DNA profiling to assess freshwater performance of wild, farmed and hybrid progeny in a natural river environment. J. Marine Sci. 54: 998-1008.

Reisenbichler, R.R. and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, Salmo gairdneri. J. Fish. Res. Board Can. 34:123 128.

Swain, D.P. and B.E. Riddell. 1990. Variation in agonistic behavior between newly emerged juveniles from hatchery and wild populations of coho salmon, Oncorhynchus kisutch. Can J. Fish. Aquat. Sci. 47:566-571.